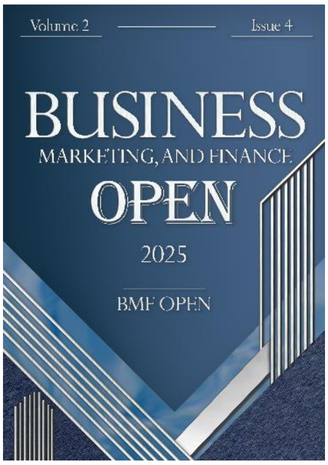
Investigating the Effect of Oil Revenues on Herding Behavior in the Tehran Stock Exchange: An Analysis Based on the FAVAR Model

Elham Mohammadi[1,*], Sajjad Barkhordari[2] and Mohsen Mehrara[3]

[1] Ph.D. Student of Economics, Alborz Campus, University of Tehran, Tehran, Iran;
[2] Associate Professor of Economics, Faculty of Economics, University of Tehran, Tehran, Iran;
[3] Professor of Economics, Faculty of Economics, University of Tehran, Tehran, Iran;

* Correspondence: e_mohamadi@pnu.ac.ir



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Abstract: The efficiency and dynamics of the stock exchange are significantly influenced by investor behavior. One of the key behavioral patterns affecting this market is the phenomenon of herding behavior, which can lead to irrational fluctuations, the formation of price bubbles, and ultimately a decrease in market efficiency. This behavior is particularly crucial in oil-dependent economies, as oil price fluctuations directly affect not only national revenues but also the stability of financial markets. In this regard, the present study examines the relationship between changes in oil revenues and herding behavior in Iran's stock market. To achieve this objective, quarterly data on 62 economic variables from Iran and the global economy were used for the period from 2001 to 2021. Furthermore, since herding behavior is an unobservable variable, it was first quantified using the method proposed by Hwang and Salmon (2004). In the second stage, the effect of oil revenues on this variable was investigated using the FAVAR model. The results of this study indicate that herding behavior has intensified in the Iranian stock market over the past decade, peaking in 2019 and 2020. The results obtained from the impulse response functions confirm that the oil revenue variable has a negative and statistically significant impact on the herding behavior variable. Based on the results of the variance decomposition of the herding behavior variable, oil revenues were able to explain up to 6.2 percent of the changes in the herding behavior variable.

Keywords: Oil Revenues, Herding Behavior, Tehran Stock Exchange, FAVAR Model.

1. Introduction

The stock exchange is one of the fundamental pillars of every national economy and plays a crucial role in the optimal allocation of financial resources. Investor behavior in this market has a direct impact on its efficiency and dynamism [1, 2]. One of the important behavioral patterns in this financial market is herding behavior, which can lead to stock market fluctuations and decreased efficiency. Herding behavior in financial markets refers to the tendency of investors to disregard individual information and make investment decisions solely based on the collective actions of the market [3, 4]. This behavior can cause prices to deviate from their fair value, increase volatility, and reduce investor confidence. In developing markets, herding behavior can lead to financial instability, market manipulation, investor discouragement, and a decline in the integrity of the monetary system.

In oil-exporting countries, fluctuations in oil revenues have a significant impact on the economy and the stock market and can also stimulate herding behavior in other related markets. Various geopolitical factors, levels of oil production and consumption, OPEC policies, and international sanctions influence oil price volatility and, consequently, oil revenues . Prior related studies have mainly focused on stock markets in developed countries such as the United States and Europe, and fewer have examined the impact of oil revenues on herding behavior in the stock markets of developing nations. Various studies show that the influence of herding behavior increases during periods of crisis, high market volatility, and economic uncertainty [5-7].

Such behavior is largely inconsistent with the efficient market hypothesis, which assumes that all investors are rational and use all available information optimally in pricing stocks [8]. It appears that in the two mentioned periods (and other similar periods such as 2003 and 2010), there was a deviation from the efficient market hypothesis, and investors exhibited behavioral biases highly similar to herding behavior. This behavior may result in adverse outcomes such as bubble formation, suboptimal resource allocation, and more [9].

A review of the literature reveals extensive international and domestic research into the determinants of herding behavior in financial markets. Chang et al. (2000) identified significant herding across both developed and developing markets through a nonlinear negative relationship between cross-sectional dispersion and average market returns [10]. In contrast, Hwang and Salmon (2004) introduced a nonparametric method using firm betas, showing herding arises when all betas converge toward one, reflecting uniform sensitivity to market movements—a phenomenon estimated via Kalman filtering [11]. Subsequent studies emphasized herding under stress or crisis conditions [12, 13], while Prasad et al. (2012) and Houda & Mohamad (2013) observed herding primarily during market upswings or information asymmetries [14]. Regional studies, including Gong and Dai (2017) on China [15], and Nair et al. (2017) and Mand et al. (2018) on India and Malaysia respectively [4, 16], emphasized economic, demographic, and behavioral influences. Krokida et al. (2020), using the FAVAR model, found central bank policies significantly explained herding variance in the U.S. and Europe [17]. In oil-exporting nations, fluctuations in oil prices and speculation have been found to modulate herding, with speculative oil trading sometimes reducing herding behavior [18]. Domestically, Khodaparast-Shirazi et al. (2011) confirmed that firm characteristics and liquidity mediate herding in the Tehran Stock Exchange [19]. Asadi et al. (2022) linked gold and currency fluctuations to herding in Iran's stock market [20], while Mahboubi et al. (2023) highlighted macroeconomic volatility as a driver of stock return fluctuations [21]. Behnoud and Erfani (2023) used the TVP-FAVAR model to demonstrate that expansionary monetary policy shocks had a measurable influence on beta herding between 2009 and 2021, peaking from 2013 to 2019 [22]. Overall, the literature indicates that oil revenues, exchange rates, monetary policy, and macroeconomic instability play pivotal roles in triggering herding behavior, though methodological challenges have limited deeper inquiry into this multifaceted phenomenon.

Given the importance of oil revenues for Iran's economy and the impact of their fluctuations on the Tehran Stock Exchange—a key component of the financial market—identifying the factors that influence herding behavior in this market is of considerable significance. Accordingly, this study evaluates the effect of changes in oil revenues on herding behavior in the stock market. For this purpose, the FAVAR (Factor-Augmented Vector Autoregression) approach is employed. The main advantage of this method, which makes it suitable for the present study, is that unlike the traditional vector autoregression (VAR) method that is constrained by the number of variables and the information used from them, the FAVAR approach imposes no such limitation on the number of variables included in the model. This allows for the incorporation of a wide range of important economic variables to achieve more accurate model estimation. This feature of the FAVAR model is particularly valuable for the present study, as the stock market can be influenced by a broad spectrum of variables. Limiting the number of variables under traditional methods may result in model misspecification and biased findings.

2. Methodology

As previously mentioned, the objective of this study is to investigate the impact of oil revenues on herding behavior in the Tehran Stock Exchange. The first challenge in this context is the quantification of the herding behavior variable, and the second is the evaluation of this variable within a comprehensive model. To quantify herding behavior, the nonparametric approach of Hwang and Salmon (2004), which is based on variations in systematic risk, is employed using quarterly data from 389 listed companies over the period from 2001 to 2021.

To construct a comprehensive model for the Iranian economy that avoids the specification errors commonly found in standard vector autoregression (VAR) models, the Factor-Augmented Vector Autoregression (FAVAR) method is used. In the FAVAR model, the variable selection approach involves, first, including one or more representative variables from each sector of the economy and, second, ensuring these variables are the best representatives for their respective sectors. Additionally, limitations due to the availability of quarterly data over the study period meant that not all existing variables could be used, resulting in the selection of 62 primary variables. The oil revenue variable is included as the observed endogenous variable (denoted by Y_t), while approximately 61 other variables (including those related to the stock market, currency market, monetary and credit variables, and several macroeconomic indicators) are used to construct the factors (denoted by f_t). To evaluate the relationship between oil revenues and herding behavior, impulse response functions and variance decomposition are utilized.

Hwang and Salmon (2004) argue that when the stock market is in equilibrium and there is no herding behavior or other disruptions, the Capital Asset Pricing Model (CAPM) holds [11]. According to their theory, under equilibrium conditions, there is a relationship between the return of each stock and the market return as expressed in Equation 1:

$$E_t (r_{it}) = \beta_{imt} E_t (r_{mt}) \qquad (1)$$

In this equation, r_{it} is the return of stock i at time t, and r_{mt} is the market return at time t. β_{imt} represents the measure of systematic risk, and $E_t (r_{mt})$ denotes conditional expectations based on information available up to time t. Under the standard CAPM, β_{imt} is assumed to be constant over time. However, there is considerable evidence indicating that β_{imt} changes over time. One of the most significant reasons for this variation is the emergence of herding behavior in the market, which pushes the market away from its rational equilibrium. When herding occurs, the equilibrium relationship described in Equation 1 no longer holds, and both the beta coefficient and the expected return become biased. Accordingly, the equilibrium relationship is replaced by another, as expressed in Equation 2:

$$\frac{E_t^b (r_{it})}{E_t (r_{mt})} = \beta_{imt}^b = \beta_{imt} - h_{mt} (\beta_{imt} - 1) \qquad (2)$$

Here, $E_t^b (r_{it})$ and β_{imt}^b denote the biased conditional expectation of the return for stock i and the biased beta of stock i at time t, respectively. The variable h_{mt} is a latent variable indicating the intensity of herding behavior in the stock market. When h_{mt} equals zero, no bias is present, and beta equals its equilibrium value. In the extreme case where h_{mt} equals one, the biased beta becomes one, implying that pricing decisions for a stock are entirely driven by market returns, establishing a one-to-one correspondence between market and individual stock returns. Thus, herding behavior can be measured through the variable h_{mt}. However, since in Equation 2

h_{mt} is latent and β_{imt} is unobservable (what is observed is the biased beta, not the equilibrium beta), it is not straightforward to measure the intensity of herding behavior.

Because herding behavior pertains to the entire market and is not unique to a particular stock—in essence, it is a market-wide characteristic—it is assumed that Equation 2 applies to the entire market. Accordingly, herding behavior is calculated using all stocks in the market, rather than relying on any specific one. Given that the cross-sectional average of β_{imt}^b is always equal to one, the cross-sectional standard deviation of β_{imt}^b can be defined as follows:

$$\begin{aligned} Std_c(\beta_{imt}^b) &= \sqrt{E_c((\beta_{imt} - h_{mt}(\beta_{imt} - 1) - 1)^2)} \\ &= \sqrt{E_c((\beta_{imt} - 1)^2)}\,(1 - h_{mt}) \\ &= Std_c(\beta_{imt})(1 - h_{mt}) \qquad (3) \end{aligned}$$

Here, E_c and Std_c represent the cross-sectional expectation and standard deviation, respectively. In the above equation, the standard deviation of the biased beta consists of two components: the first, $Std_c(\beta_{imt})$, is the equilibrium standard deviation of beta; the second component, $(1 - h_{mt})$, serves as the measure of herding behavior.

To extract h_{mt} from Equation 3, we first take the logarithm of the equation:

$$\log[Std_c(\beta_{imt}^b)] = \log[Std_c(\beta_{imt})] + \log(1 - h_{mt}) \qquad (4)$$

Since most of the changes over time in the beta coefficient in Equation 3 are due to herding behavior and equilibrium beta typically does not change easily, it is expected that the cross-sectional standard deviation of the equilibrium beta, $Std_c(\beta_{imt})$, will be constant over time or vary randomly with minor fluctuations. Therefore, the equilibrium standard deviation can be expressed as the sum of a fixed and a random component:

$$\log[Std_c(\beta_{imt})] = \mu_m + \upsilon_{mt} \qquad (5)$$

where $\mu_m = E[\log[Std_c(\beta_{imt})]]$ and $\upsilon_{mt} \sim iid(0, \sigma_{mv}^2)$. Based on this, Equation 4 can be rewritten as:

$$\log[Std_c(\beta_{imt}^b)] = \mu_m + \upsilon_{mt} + H_{mt} \qquad (6)$$

where $H_{mt} = \log(1 - h_{mt})$. H_{mt} is the variable representing herding behavior. Herding does not disappear from the market suddenly; it may take several periods for it to subside. For modeling herding behavior, two processes can be considered: a random walk or an AR(1) process. In the random walk scenario, based on Equation 7, $\varphi = 1$, which implies that once herding emerges in the market, it persists indefinitely. However, if $\varphi < 1$, it means herding behavior corrects itself after a number of periods, which is more consistent with reality. Accordingly, we assume this variable follows a dynamic process such as AR(1):

$$\begin{aligned} \log[Std_c(\beta_{imt}^b)] &= \mu_m + \upsilon_{mt} + H_{mt} \\ H_{mt} &= \varphi_m H_{(mt-1)} + \eta_{mt} \qquad (7) \end{aligned}$$

where $\eta_{mt} \sim iid(0, \sigma_{m\eta}^2)$. Equation 7 specifies a standard state-space model, which can be readily estimated using the Kalman filter method.

3. Findings and Results

Oil revenues are among the primary variables influencing herding behavior in the stock markets of oil-exporting countries. Figure 1 shows the trend of Iran's oil exports in millions of dollars. During the 2000s and 2010s, two entirely contrasting trends are evident in Iran's oil export trajectory. The upward trend in oil prices in the 2000s, reaching new price peaks (in some periods even exceeding 120 dollars), along with increased oil production and export capacity, led to a significant rise in oil revenues throughout the decade, continuing until its end. However, just as these revenues peaked, oil prices declined slightly, and the first round of sanctions—including oil export sanctions—was imposed on Iran's economy, initiating a downward trend in oil revenues.

During 2016 and 2017, prior to the United States' unilateral withdrawal from the JCPOA, oil revenues increased to some extent. However, this period coincided with a time when oil prices were relatively low compared to previous years. Thus, despite an increase in export volume, the rise in oil revenues was not substantial enough to return to pre-sanctions levels. In 2018, with the onset of the second round of oil sanctions, Iran experienced a notable decline in oil revenues. In some of the early months of the second sanctions round, Iran's oil exports fell to as low as 200,000 barrels per day, marking one of the most significant historical declines in oil revenue.

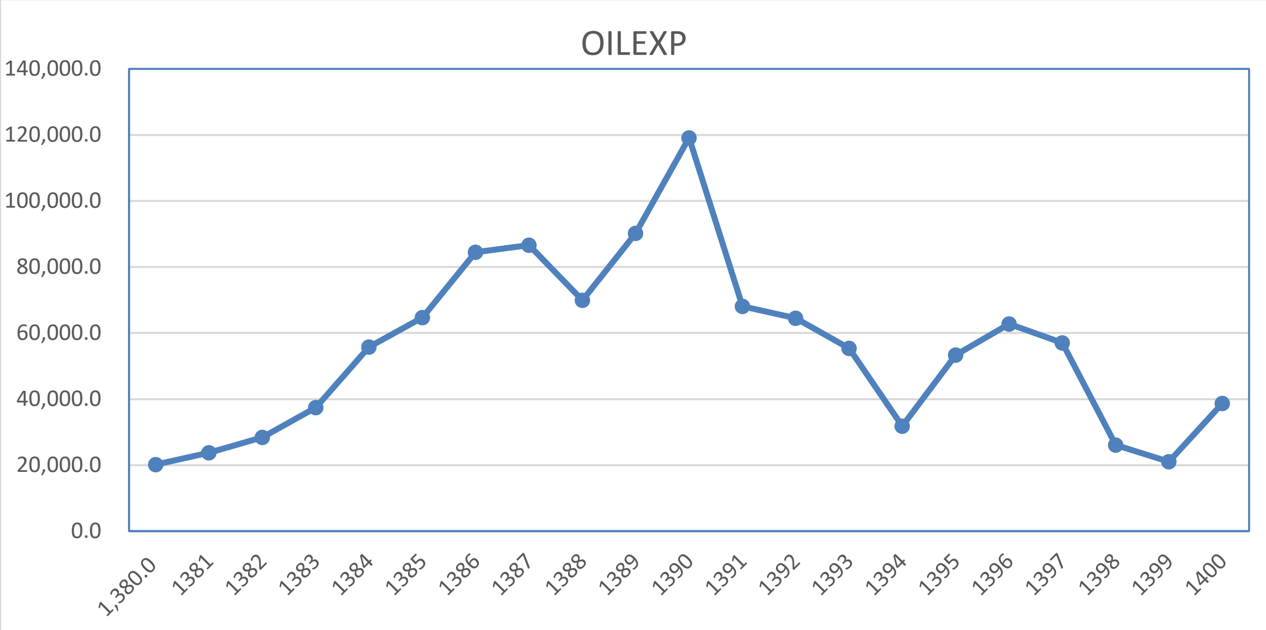

Figure 1. Iran's Oil Export Trend (Million Dollars)

As mentioned in the methodology section, this study uses the detailed herding behavior measure by Hwang and Salmon (2004), a nonparametric method based on changes in systematic risk. To calculate herding behavior in the stock market, data from 389 listed companies were used. Due to the long duration of the study and the fact that some companies were not listed on the exchange in the early years, the number of companies varied over time. Herding behavior in each period was calculated based on available data.

To estimate individual stock returns, a rolling window approach was applied. In Excel, a regression was performed with the dependent variable being the daily closing prices of each stock symbol, and the independent variable being the overall market index. The number of observations used in each regression corresponded to the length of the rolling window.

After obtaining the return of each stock (β_imt^b), the cross-sectional standard deviation of the biased beta (Std_c (β_imt^b)) needed to be calculated. This was done using Excel's standard deviation function and based on the returns obtained for different stocks on a given day. A higher standard deviation indicates less herding behavior.

Next, to quantify the herding behavior variable, which is latent and unobservable, the state-space approach and Kalman filter were used—methods suited for estimating and forecasting unobservable variables. The estimation results are presented in Table 1. As shown in the table, the coefficient C(4), which represents the autoregressive coefficient of the herding behavior variable, was estimated at 0.96—considered a high value. The larger this coefficient, the more persistent the herding behavior. In other words, if a shock occurs that triggers herding behavior in the market, it will take a relatively long time for the effect of that shock to dissipate. Thus, herding behavior tends to persist and is not typically a short-term phenomenon.

Table 1. Estimation Results of the Herding Behavior Equation

Variable	Coefficient	Standard Error		z-Statistic	p-Value
C(1)	0.46	0.39		1.18	0.238
C(2)	-2.88	0.14		-20.83	0.000
C(3)	-3.19	0.23		-13.94	0.000
C(4)	0.96	0.02		43.27	0.000
Variable	Final State	RMSE	z-Statistic	p-Value	
SV1	-0.91	0.26	-3.43	0.001	

Figure 2 presents the trend of the herding behavior variable calculated using the Hwang and Salmon (2004) method. As shown in the figure, during the 2000s, the herding behavior index remained in the positive range. However, upon entering the 2010s, the index shifted into negative territory and remained there for most periods. It is important to note that the interpretation of this extracted index is such that an increase in the index indicates a *decrease* in herding behavior, while a decrease in the index indicates an *increase* in herding behavior. This interpretation is based on how the index is calculated. Figure 2 illustrates the trend of the variable H_mt, calculated using the formula H_mt = (1 − h_mt), where h_mt represents the level of herding behavior. As the chart demonstrates, although there were fluctuations in herding behavior until 2011, its overall level remained relatively low compared to the 2011–2021 period. Figure 2 suggests that the economic crises in Iran during the past decade intensified herding behavior. This is consistent with expectations: during economic or market crises, individuals often find it difficult to accurately assess conditions and, as a result, disregard their private information and instead base their decisions on the behavior of others (Christie & Huang, 1995). Interestingly, during the second round of sanctions, the calculated index reached its lowest historical level, indicating that the intensity of herding behavior was significantly greater than in the first round. Part of this phenomenon may relate to the fact that economic actors recalled their experience from the first round of sanctions and, without evaluating the new situation, chose to react based solely on prior experience and the behavior of other market participants. Consequently, since late 2017, when the second round of sanctions began, there has been excessive coordination among economic actors and heightened herding behavior in the market.

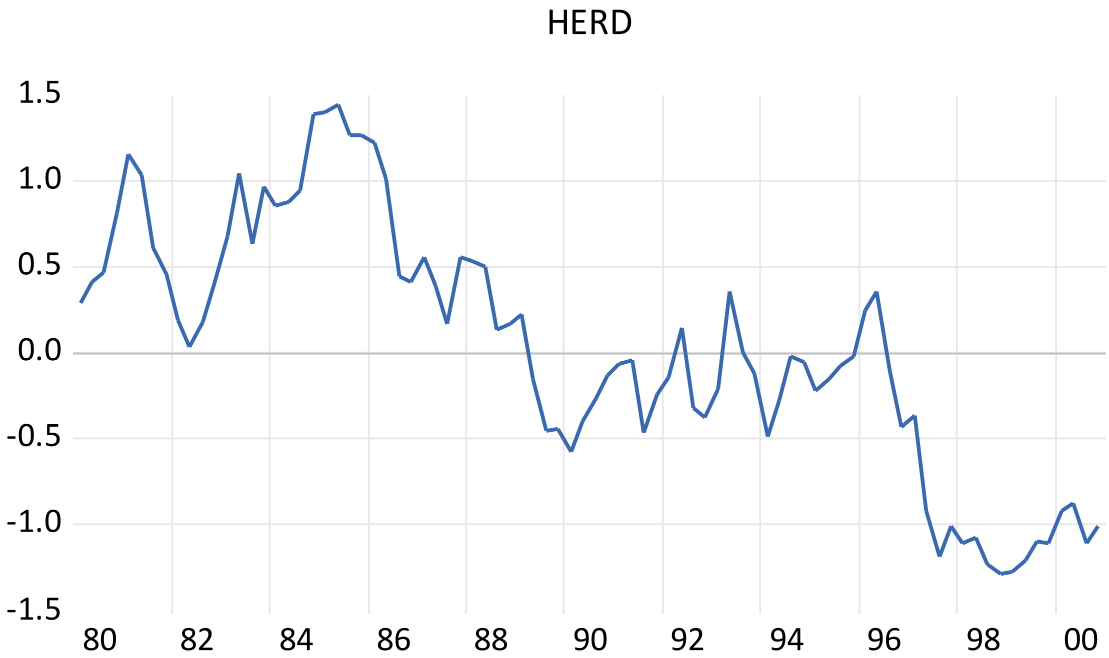

Figure 2. Trend of the Herding Behavior Variable

The next step is to assess the extent to which oil revenues have influenced the formation of herding behavior in Iran's economy. Figure 3 shows the scatter plot of oil revenue growth and the herding behavior variable. As depicted in the figure, there is a positive relationship between herding behavior and oil revenues. In other words, as oil revenues increase, the herding behavior variable also increases. However, as noted in the previous section, the interpretation of this relationship must be reversed, due to the nature of the herding behavior index. Therefore, Figure 3 actually indicates that during periods of declining oil revenues—i.e., when oil revenues face reductions—there is a corresponding increase in the intensity of herding behavior in the stock market. Oil is a critical factor influencing the economy in oil-exporting countries. A substantial portion of economic growth in these countries is driven by the oil sector, and industrial investments and the import of essential inputs are largely dependent on foreign currency obtained through oil exports. In the absence of oil revenues, particularly when those revenues are abruptly cut off, an atmosphere of uncertainty emerges regarding the economy's outlook and corporate profitability. This ultimately prompts uninformed investors to align their decisions with the actions of others, thus triggering herding behavior.

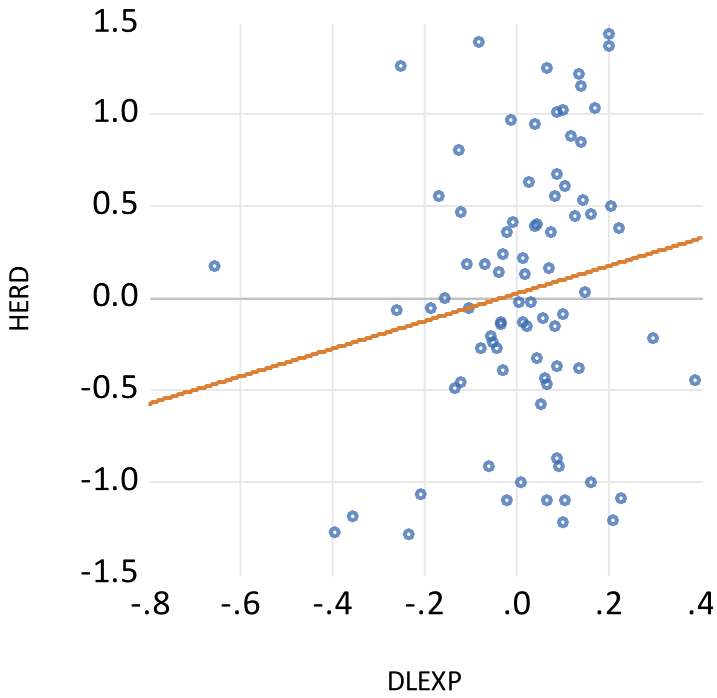

Figure 3. Relationship Between Oil Revenues and the Herding Behavior Variable

In this section, to examine the effect of oil revenues on herding behavior, the same methodological approach used previously is applied. The only difference is that instead of the exchange rate variable, which was used as the observed variable (Y) in the earlier section, oil revenues are now used in that role. This adjustment is necessary because, within the FAVAR model framework introduced by Bernanke et al. (2005), in order to introduce a shock to a variable and monitor the responses of other variables, that variable must be considered the observed variable (Y). Accordingly, the FAVAR model was estimated with oil revenues as the observed variable, and the results are reported below. The model estimation approach is identical to what was previously explained in full detail. As the first step, the number of factors to include in the model was determined. The results from the methods proposed by Bai and Ng (2002) and by Ahn and Horenstein (2013) were identical to the previous case. The stability of the results is due to the fact that only a very minor change was made to the model: all variables used in the model remain exactly the same, with the sole difference being the substitution of the exchange rate variable with the oil revenue variable.

In the next step, the number of lags in the FAVAR model was determined based on the Akaike Information Criterion (AIC). The AIC suggested using four lags, and estimating the model with this number of lags satisfied the classical assumptions of the model. Therefore, the FAVAR model was estimated using four lags.

The results obtained from the impulse response functions indicate that the oil revenue variable has a negative and statistically significant effect on the herding behavior variable (as noted earlier, the interpretation of the results must be in the reverse direction). This outcome is entirely consistent with expectations. In oil-exporting countries, there is strong dependency on oil revenues, and a decline in these revenues can lead to severe challenges for the overall economy, including reduced investment, difficulties in supplying inputs for industrial units, government budget deficits, diminished foreign currency supply, increased inflation, higher taxes to offset budget deficits, and elevated economic uncertainty. Given the various mechanisms through which the oil revenue variable affects the economies of oil-exporting countries, it is unsurprising that economic agents consistently consider this variable in their investment decisions. When a decline occurs in this variable, due to its multifaceted impact on the economy, uncertainty intensifies considerably, making rational and informed decision-making more difficult for economic agents. Consequently, many stock market participants, in order to avoid error and due to various psychological biases that can disrupt sound economic reasoning, resort to herding behavior and prefer to follow the crowd, interpreting collective behavior as the correct response to emerging conditions.

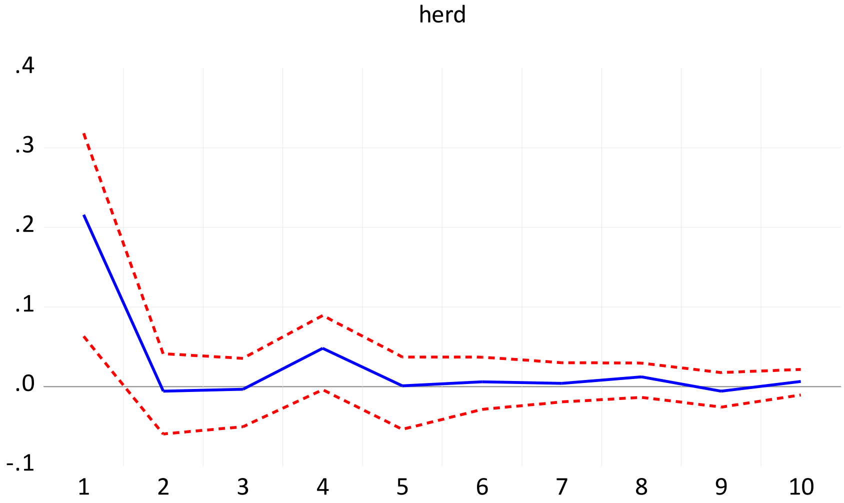

Figure 3. The Effect of Oil Revenues on the Herding Behavior Index Considering Two Factors

According to Figure 3, the oil revenue variable has only a contemporaneous effect on the herding behavior variable, impacting it only in the first period, with its influence dissipating thereafter. In subsequent periods, no statistically significant effect of oil revenues on herding behavior is observed. In other words, due to the importance of this variable, all stock market investors closely monitor changes in it, and thus, the herding behavior response occurs immediately within the same period.

Table 2. Variance Decomposition Results for the Herding Behavior Variable Considering Two Factors

Variable	Share of Oil Revenue Variable in Forecast Error Variance	R^2
HERD	0.062	0.090

Table 2 presents the variance decomposition results for the herding behavior variable. As shown, the oil revenue variable accounts for 6.2% of the variation in the herding behavior variable. Although this is less than the effect of the exchange rate variable on herding behavior, it is still a considerable figure. As previously explained, it should not be expected that a complex variable like herding behavior, which is influenced by numerous psychological factors, can be easily explained using economic variables. The aim here is merely to identify those variables that play a role in triggering herding behavior. The lack of a lagged effect and the confinement of the oil revenue variable's influence to the initial period support this claim. In fact, changes in oil revenues only affect the onset of herding behavior (i.e., the first period), and subsequent changes in this variable have little influence on the behavior in later periods.

The above results were obtained by considering two factors in the FAVAR model. If we increase the number of factors to three, the results do not change significantly, and the impulse response functions and variance decomposition remain similar to the previous case (Figure 4).

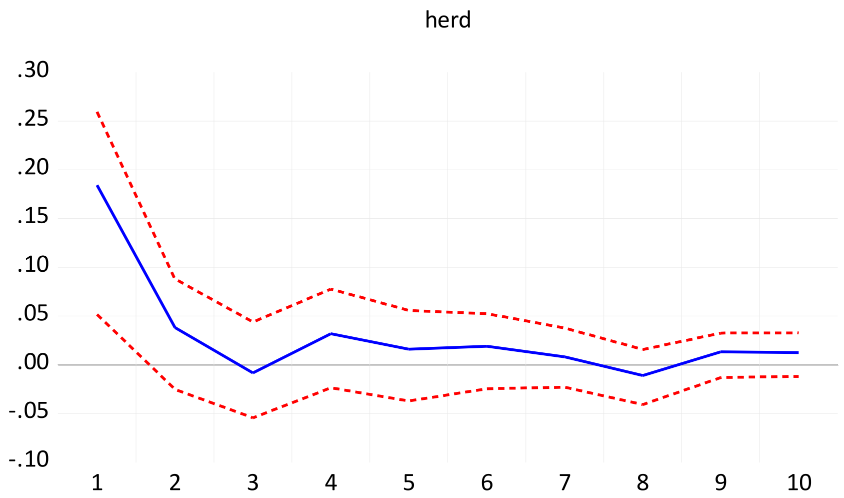

Figure 4. The Effect of Oil Revenues on the Herding Behavior Index Considering Three Factors

The variance decomposition results in the case where three factors are included in the model (Table 3) show little change; the only difference is a slight increase in the model's explanatory power and a small reduction in the share of the oil revenue variable in explaining the variance of the herding behavior variable.

Table 3. Variance Decomposition Results for the Herding Behavior Variable Considering Three Factors

Variable	Share of Oil Revenue Variable in Forecast Error Variance	R^2
HERD	0.044	0.147

4. Discussion and Conclusion

The primary objective of this study was to examine the effect of oil revenues on herding behavior in Iran's stock market. To this end, data from the Iranian economy covering the period from the first quarter of 2001 to the last quarter of 2021 were utilized, and the relationship between these two variables was analyzed using the FAVAR model. Since herding behavior is an unobservable variable, it was first quantified using the method proposed by Hwang and Salmon (2004) [11], and then, within the framework of a 62-variable model—including the key economic variables of both Iran and the global economy—the impact of oil revenues on herding behavior in the stock market was evaluated.

The results obtained from the impulse response functions indicate that oil revenues have a negative and statistically significant effect on herding behavior. This finding is entirely consistent with expectations, as oil-exporting countries exhibit strong dependence on oil revenues, and a decline in these revenues can subject the general economic condition to a wide range of challenges, including reduced investment, difficulties in securing production inputs for industrial units, government budget deficits, diminished foreign currency supply, inflation, increased taxation to offset revenue shortfalls, and heightened economic uncertainty. Given the various mechanisms through which oil revenues influence the economies of oil-exporting nations, it is unsurprising that economic agents consistently consider this variable in their investment decisions.

When reductions occur in this variable, the resultant increase in economic uncertainty—due to the multifaceted influence of oil revenues—makes rational and fully informed decision-making exceedingly difficult for economic actors. Therefore, many economic agents and stock market investors, in an effort to avoid making erroneous decisions and also due to various psychological biases that can impair sound economic judgment, resort to herding behavior and prefer to follow the crowd, accepting collective behavior as the correct response to emerging conditions.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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